

CLAIMS

We claim:

1 1. An apparatus for excluding ferromagnetic and magnetic objects from
2 proximity to an MRI instrument, comprising:
3 an array of sensors adapted to sense a magnetic field of an object;
4 a processor adapted to interpret signals from said sensor array sensing said
5 magnetic field to detect said object; and
6 a scanner chassis on which said sensor array is mounted, said scanner chassis
7 being adapted to position the entirety of said sensor array in proximity to
8 all portions of a human subject, said scanner chassis being adapted to
9 orient said sensor array to distinguish between a background magnetic
10 field and said magnetic field of said object.

1 2. The apparatus recited in claim 1, wherein:
2 said object is a “soft” ferromagnetic object; and
3 said magnetic field comprises an induced magnetic field caused by magnetization
4 of said ferromagnetic object by an external magnetic field.

1 3. The apparatus recited in claim 1, wherein said object comprises a
2 permanently magnetic object.

1 4. The apparatus recited in claim 1, wherein said processor is further adapted
2 to interpret signals from said sensor array sensing said magnetic field to characterize said
3 object.

1 5. The apparatus recited in claim 1, wherein said processor is further adapted
2 to interpret signals from said sensor array sensing said magnetic field to locate said
3 object.

1 6. The apparatus recited in claim 1, wherein said scanner chassis comprises a
2 portal structure, said portal structure having at least first and second vertical members,
3 one of said vertical members being arranged on each side of a passageway adapted for
4 passage of a recumbent human subject.

1 7. The apparatus recited in claim 6, wherein:
2 said sensor array comprises at least first and second sensor sub-arrays;
3 said first sensor sub-array is arranged horizontally on said first vertical member
4 on a first side of said passageway;
5 said second sensor sub-array is arranged horizontally on said second vertical
6 member on a second side of said passageway; and
7 said first and second sensor sub-arrays are positioned at a height matching a
8 selected height at which said recumbent human subject will pass through
9 said portal structure.

1 8. The apparatus recited in claim 6, wherein:
2 said portal structure further comprises a horizontal member spanning said
3 passageway between said first and second vertical members;
4 said sensor array comprises at least one sensor sub-array arranged horizontally on
5 said horizontal member; and
6 said sensor sub-array is arranged above said passageway, at a height above, but in
7 close proximity to, a selected height at which said recumbent human
8 subject will pass through said portal structure.

1 9. The apparatus recited in claim 8, wherein:
2 said horizontal member has a scanning position spanning said passageway at an
3 intermediate height relative to said first and second vertical members, said
4 scanning position limiting the clear height of said passageway between
5 said first and second vertical members to said intermediate height; and
6 said horizontal member has a non-scanning position, said non-scanning position
7 not spanning said passageway at said intermediate height, said non-
8 scanning position increasing said clear height of said passageway to allow
9 passage of an upright human subject through said portal structure.

1 10. The apparatus recited in claim 9, wherein:
2 said sensor array comprises at least three said sensor sub-arrays;
3 a first said sensor sub-array is arranged horizontally on said horizontal member;
4 a second said sensor sub-array is arranged vertically on said first vertical member;
5 a third said sensor sub-array is arranged vertically on said second vertical
6 member; and
7 when said horizontal member is in said non-scanning position, said second and
8 third sensor sub-arrays are adapted to scan said upright human subject
9 passing through said portal structure.

1 11. The apparatus recited in claim 1, wherein said scanner chassis comprises a
2 hand-held frame.

1 12. The apparatus recited in claim 11, wherein:
2 said object is a “soft” ferromagnetic object; and
3 said magnetic field comprises an induced magnetic field caused by magnetization
4 of said ferromagnetic object by an external magnetic field.

1 13. The apparatus recited in claim 12, further comprising a source of said
2 external magnetic field mounted on said hand-held frame.

1 14. The apparatus recited in claim 13, wherein said source of said external
2 magnetic field comprises a permanent magnet.

1 15. The apparatus recited in claim 13, wherein said source of said external
2 magnetic field comprises an electromagnetic coil.

1 16. The apparatus recited in claim 15, wherein said electromagnetic coil is
2 driven by a DC source.

1 17. The apparatus recited in claim 15, wherein said electromagnetic coil is
2 driven by an AC source.

1 18. The apparatus recited in claim 17, wherein said AC source operates at a
2 frequency less than about 1000 Hz.

1 19. The apparatus recited in claim 13, wherein said sensor array comprises at
2 least two sensors, said at least two sensors being arranged symmetrically relative to said
3 magnetic field source, said at least two sensors being connected to cancel out their
4 respective signals resulting from exposure to the flux of said magnetic field source.

1 20. The apparatus recited in claim 19, wherein said at least two sensors
2 comprise induction coils.

1 21. The apparatus recited in claim 20, wherein each said induction coil is
2 wound on a magnetically impermeable core.

1 22. The apparatus recited in claim 20, wherein each said induction coil is
2 wound on a magnetically permeable core.

1 23. The apparatus recited in claim 19, wherein said at least two sensors
2 comprise magnetometers.

1 24. An apparatus for excluding ferromagnetic objects from proximity to an
2 MRI instrument, comprising:
3 a portal structure, said portal structure having at least first and second vertical
4 members, one of said vertical members being arranged on each side of a
5 passageway adapted for passage of a recumbent human subject, said portal
6 structure having a horizontal member spanning said passageway between
7 said first and second vertical members;
8 an array of sensors arranged horizontally on said horizontal member, said sensor
9 array being adapted to detect an induced magnetic field caused by
10 magnetization of a ferromagnetic object by an external magnetic field,
11 said sensor array being adapted to distinguish between a background
12 magnetic field and said induced magnetic field of said ferromagnetic
13 object, said sensor sub-array being arranged above said passageway, at a
14 height above, but in close proximity to, a selected height at which said
15 recumbent human subject will pass through said portal structure; and
16 a processor adapted to interpret signals from said sensor array to detect said
17 ferromagnetic object according to said induced magnetic field.

1 25. The apparatus recited in claim 24, wherein:
2 said horizontal member has a scanning position spanning said passageway at an
3 intermediate height relative to said first and second vertical members, said
4 scanning position limiting the clear height of said passageway between
5 said first and second vertical members to said intermediate height; and
6 said horizontal member has a non-scanning position, said non-scanning position
7 not spanning said passageway at said intermediate height, said non-
8 scanning position increasing said clear height of said passageway to allow
9 passage of an upright human subject through said portal structure.

1 26. The apparatus recited in claim 25, further comprising first and second
2 vertical sensor arrays, wherein:

3 said first vertical sensor array is arranged vertically on said first vertical member;
4 said second vertical sensor array is arranged vertically on said second vertical
5 member; and
6 when said horizontal member is in said non-scanning position, said first and
7 second vertical sensor arrays are adapted to scan said upright human
8 subject passing through said portal structure.

1 27. An apparatus for excluding ferromagnetic objects from proximity to an
2 MRI instrument, comprising:

3 a hand-held frame;
4 a magnetic field source mounted on said hand-held frame;
5 an array of at least two sensors mounted on said hand-held frame, said array of
6 sensors being adapted to detect an induced magnetic field caused by
7 magnetization of a ferromagnetic object by a magnetic field from said
8 source, said at least two sensors being arranged symmetrically relative to
9 said magnetic field source, said at least two sensors being connected to
10 cancel out their respective signals resulting from exposure to the flux of
11 said magnetic field source;
12 a processor adapted to interpret signals from said sensor array to detect said
13 ferromagnetic object according to said induced magnetic field.

1 28. The apparatus recited in claim 27, wherein said source of said magnetic
2 field comprises a permanent magnet.

1 29. The apparatus recited in claim 27, wherein said source of said magnetic
2 field comprises an electromagnetic coil.

1 30. The apparatus recited in claim 29, wherein said electromagnetic coil is
2 driven by a DC source.

1 31. The apparatus recited in claim 29, wherein said electromagnetic coil is
2 driven by an AC source.

1 32. The apparatus recited in claim 31, wherein said AC source operates at a
2 frequency less than 1000 Hz.

1 33. The apparatus recited in claim 27, wherein said at least two sensors
2 comprise induction coils.

1 34. The apparatus recited in claim 33, wherein each said induction coil is
2 wound on a magnetically impermeable core.

1 35. The apparatus recited in claim 33, wherein each said induction coil is
2 wound on a magnetically permeable core.

1 36. The apparatus recited in claim 27, wherein said at least two sensors
2 comprise magnetometers.

1 37. A method for excluding objects from proximity to an MRI instrument,
2 said method comprising:

3 providing an array of sensors adapted to detect a magnetic field of an object;

4 positioning the entirety of said sensor array to scan all portions of a human

5 subject;

6 processing signals from said sensor array to detect said object.

1 38. The method recited in claim 37, wherein said object comprises a
2 ferromagnetic object having an induced magnetic field, said method further comprising
3 orienting said sensor array relative to a source of an external magnetic field to distinguish
4 between said external magnetic field and said induced magnetic field of said
5 ferromagnetic object.

1 39. The method recited in claim 37, further comprising:
2 mounting said sensor array on a portal structure; and
3 passing a recumbent patient through said portal structure to accomplish said
4 positioning of said sensor array to scan said recumbent human subject.

1 40. The method recited in claim 39, further comprising:
2 providing said sensor array as at least two sensor sub-arrays;
3 mounting a first said sensor sub-array on a movable horizontal member on said
4 portal structure;
5 mounting a second said sensor sub-array on at least one vertical member on said
6 portal structure;
7 passing said recumbent patient through said portal structure, beneath said
8 horizontal member, to accomplish positioning of said first sensor sub-
9 array to scan said recumbent human subject;
10 moving said horizontal member to clear a passageway through said portal
11 structure for an upright human subject, said passageway being adjacent to
12 said at least one vertical member; and
13 passing said upright human subject through said passageway to scan said upright
14 human subject.

1 41. The method recited in claim 37, further comprising:
2 mounting said sensor array on a hand-held frame;
3 providing a source of an external magnetic field mounted to said hand-held frame;
4 orienting said sensor array relative to said hand-held frame to distinguish between
5 said external magnetic field and an induced magnetic field of said object;
6 and
7 passing said hand-held frame over said human subject to accomplish said
8 positioning of said entire sensor array to scan said human subject.